CLAIMS

I/We claim:

[c1] 1. A microelectronic device, comprising a microelectronic substrate having a first surface, a second surface facing opposite from the first surface, and a plurality of active devices at least proximate to the first surface, the second surface having a projected area and a plurality of heat transfer surface features integrally formed in the second surface, wherein a surface area of the second surface including the heat transfer surface features is greater than the projected area.

[c2] 2. The device of claim 1 wherein the first and second surfaces of the microelectronic substrate are generally parallel and wherein the projected area is generally parallel to the first surface.

[c3] 3. The device of claim 1 wherein the heat transfer surface features are at least partially defined by a plurality of recesses.

[c4] 4. The device of claim 1 wherein the heat transfer surface features extend a distance approximately equal to one-third to one-half of a distance between the first and second surfaces of the microelectronic substrate.

[c5] 5. The device of claim 1 wherein at least one heat transfer surface feature includes a first wall, a second wall, and a portion of the second surface between the first wall and the second wall, the first wall defining a first plane, the second wall defining a second plane generally nonparallel to the first plane.

[c6] 6. The device of claim 1 wherein at least one heat transfer surface feature includes a first wall, a second wall, and a portion of the second surface

between the first wall and the second wall, the first wall defining a first plane, the second wall defining a second plane generally parallel to the first plane.

[c7] 7. The device of claim 1 wherein the microelectronic substrate includes a microelectronic die.

[c8] 8. The device of claim 1 wherein at least one heat transfer surface feature includes a projection.

[c9] 9. The device of claim 1, further comprising a plurality of solder balls coupled to the microelectronic substrate.

[c10] 10. The device of claim 1, further comprising a plurality of electrical couplers electrically coupled to the active devices and configured to provide electrical communication between the microelectronic substrate and external components.

[c11] 11. A microelectronic device, comprising a microelectronic substrate having a first surface, a second surface facing opposite from the first surface, and a plurality of active devices at least proximate to the first surface, the second surface having a projected area and a plurality of heat transfer surface features, wherein a surface area of the second surface including the heat transfer surface features is greater than the projected area.

[c12] 12. The device of claim 11 wherein the first and second surfaces of the microelectronic substrate are generally parallel and wherein the projected area is generally parallel to the first surface.

[c13] 13. The device of claim 11 wherein the heat transfer surface features are at least partially defined by a plurality of recesses.

[c14] 14. The device of claim 11 wherein at least one h at transfer surface feature includes a projection.

[c15] 15. A microelectronic device, comprising a microelectronic substrate having a first surface, a second surface facing opposite from the first surface, and a plurality of active devices at least proximate to the first surface, the second surface having a plurality of heat transfer surface features, wherein the heat transfer surface features are not configured to provide electrical communication between the microelectronic substrate and components external to the microelectronic substrate.

[c16] 16. The device of claim 15 wherein at least one heat transfer feature is integrally formed in the second surface.

[c17] 17. The device of claim 15 wherein the first and second surfaces of the microelectronic substrate are generally parallel and wherein the projected area is generally parallel to the first surface.

[c18] 18. The device of claim 15 wherein the heat transfer surface features are at least partially defined by a plurality of recesses.

[c19] 19. The device of claim 15 wherein the heat transfer surface features extend a distance approximately equal to one-third to one-half of a distance between the first and second surfaces of the microelectronic substrate.

[c20] 20. The device of claim 15 wherein at least one heat transfer surface feature includes a first wall, a second wall, and a portion of the second surface between the first wall and the second wall, the first wall defining a first plane, the second wall defining a second plane generally nonparallel to the first plane.

[c21] 21. The device of claim 15 wherein at least one heat transfer surface feature includes a first wall, a second wall, and a portion of the second surface between the first wall and the second wall, the first wall defining a first plane, the second wall defining a second plane generally parallel to the first plane.

[c22] 22. The device of claim 15 wherein the microelectronic substrate includes a microelectronic die.

[c23] 23. The device of claim 15 wherein at least one heat transfer surface feature includes a projection.

[c24] 24. The device of claim 15, further comprising a plurality of solder balls coupled to the microelectronic substrate.

[c25] 25. The device of claim 15, further comprising a plurality of electrical couplers electrically coupled to the active devices and configured to provide electrical communication between the microelectronic substrate and external components.

[c26] 26. A microelectronic device, comprising:

a microelectronic substrate having a first surface, a second surface facing opposite to the first surface, a first side wall extending generally transverse to the second surface, a second side wall extending generally transverse to the second surface, and a plurality of active devices at least proximate to the first surface, wherein the first side wall, the second side wall, and the second surface define at least in part a thermal conductor volume; and

an enclosure member sealably coupled to the microelectronic substrate to enclose the thermal conductor volume.

[c27] 27. The device of claim 26 wherein the microelectronic substrate includes a microelectronic die.

[c28] 28. The device of claim 26, further comprising a thermal conductor disposed within the thermal conductor volume.

[c29] 29. The device of claim 26, further comprising a thermal conductor disposed within the thermal conductor volume, the thermal conductor including a first portion and a second portion, wherein the first portion is of a different phase than the second portion.

[c30] 30. The device of claim 26, further comprising at least one wick disposed at least partially within the thermal conductor volume.

[c31] 31. The device of claim 26 wherein the enclosure member includes a plurality of fins.

[c32] 32. The device of claim 26 wherein the thermal conductor volume extends into at least one groove in the microelectronic substrate.

[c33] 33. The device of claim 26 wherein the second surface has a projected area in a plane generally parallel to the first surface, and wherein the second surface includes a plurality of integrally formed heat transfer surface features, further wherein a surface area of the second surface including the heat transfer surface features is greater than the projected area.

[c34] 34. A microelectronic device, comprising:

a microelectronic substrate having a first surface, a second surface facing opposite from the first surface, and a plurality of active devices at

least proximate to the first surface, the second surface defining at least in part a thermal conductor volume;

an enclosure member sealably coupled to the microelectronic substrate to enclose the thermal conductor volume; and

a thermal conductor disposed within the thermal conductor volume.

[c35] 35. The device of claim 34 wherein the microelectronic substrate includes a microelectronic die.

[c36] 36. The device of claim 34 wherein the thermal conductor volume includes at least one groove in the microelectronic substrate.

[c37] 37. The device of claim 34 wherein the thermal conductor includes a thermally conductive solid material.

[c38] 38. The device of claim 34 wherein the thermal conductor includes a thermally conductive liquid.

[c39] 39. The device of claim 34 wherein the thermal conductor includes a thermally conductive gas.

[c40] 40. The device of claim 34 wherein the thermal conductor includes a liquid, and wherein at least some of the liquid is positioned and configured to absorb heat from the microelectronic substrate, vaporize, transfer heat to the enclosure member, and condense.

[c41] 41. The device of claim 34 wherein the thermal conductor includes a liquid, and wherein the device further comprises a wick disposed at least partially within the thermal conductor volume.

[c42] 42. The device of claim 34 wherein the enclosure member includes a plurality of heat fins.

[c43] 43. The device of claim 34 wherein the thermal conductor includes at least one of water, ammonia, and alcohol.

[c44] 44. The device of claim 34 wherein a pressure within the thermal conductor volume is less than atmospheric pressure.

[c45] 45. The device of claim 34 wherein the second surface has a plurality of recesses which define a portion of the thermal conductor volume.

[c46] 46. The device of claim 34 wherein the second surface has a projected area in a plane generally parallel to the first surface, and wherein the second surface includes a plurality of integrally formed heat transfer surface features, further wherein a surface area of the second surface including the heat transfer surface features is greater than the projected area.

[c47] 47. A microelectronic device, comprising:

a microelectronic substrate having a first surface, a second surface facing opposite the first surface, and a plurality of active devices at least proximate to the first surface, the second surface having a plurality of recesses; and

a sealed heat transport system coupled to the second surface of the microelectronic substrate, the heat transport system having a cavity with a thermal conductor configured to transfer heat from the microelectronic substrate to a region external to the microelectronic substrate, the thermal conductor being sealably excluded from the recesses.

[c48] 48. The device of claim 47 wherein the thermal conductor includ s a thermally conductive solid.

[c49] 49. The device of claim 47 wherein the thermal conductor includes a thermally conductive gas.

[c50] 50. The device of claim 47 wherein the thermal conductor includes a thermally conductive liquid.

[c51] 51. The device of claim 47 wherein the thermal conductor includes a liquid positioned and configured to absorb heat from a first portion of the sealed heat transport system, vaporize, transfer heat at least proximate to a second portion of the sealed heat transport system, and condense.

[c52] 52. The device of claim 47 wherein the plurality of recesses includes grooves.

[c53] 53. The device of claim 47 wherein the thermal conductor is the second of at least two thermal conductors, and wherein the device further comprises a first thermal conductor disposed within at least one of the recesses.

[c54] 54. The device of claim 47 wherein the thermal conductor is the second of at least two thermal conductors, and wherein the device further comprises a first thermal conductor disposed within at least one of the recesses, and wherein the first thermal conductor includes a liquid.

[c55] 55. The device of claim 47 wherein the thermal conductor is the second of at least two thermal conductors, and wherein the device further comprises a first thermal conductor disposed within at least one of the recesses, and wherein the first thermal conductor includes a thermally conductive solid.

[c56] 56. The device of claim 47 wherein the thermal conductor is the second of at least two thermal conductors, and wherein the device further comprises a first thermal conductor disposed within at least one of the recesses, and wherein the first thermal conductor includes a gas.

[c57] 57. The device of claim 47 wherein the thermal conductor is the second of at least two thermal conductors, and wherein the device further comprises a first thermal conductor disposed within at least one of the recesses, and wherein the first thermal conductor includes a liquid positioned and configured to absorb heat from the microelectronic substrate, vaporize, transfer heat to the sealed heat transport system, and condense.

[c58] 58. The device of claim 47 wherein the sealed heat transport system includes a plurality of fins.

[c59] 59. A method of making a microelectronic device, comprising:

forming active devices at least proximate to a first surface of a microelectronic substrate, the microelectronic substrate having a second surface facing opposite the first surface, the second surface having a projected area; and

removing material from the second surface of the microelectronic substrate to form heat transfer surface features, wherein a surface area of the second surface including the heat transfer surface features is greater than the projected area.

[c60] 60. The method of claim 59 wherein removing material from the second surface includes etching grooves in the second surface.

[c61] 61. The method of claim 59, further comprising disposing a thermal conductor within at least some of the recesses formed by removing material from the second surface.

[c62] 62. The method of claim 59, further comprising coupling an enclosure member to the second surface.

[c63] 63. The method of claim 59, further comprising coupling to the second surface a sealed heat transport system having a sealed cavity and a thermal conductor disposed within the cavity.

[c64] 64. A method of making a microelectronic device, comprising:

forming active devices at least proximate to a first surface of a microelectronic substrate;

forming at least one recess in a second surface of the microelectronic substrate facing opposite from the first surface;

disposing a thermal conductor in the at least one recess, wherein the thermal conductor is not configured to provide electrical communication between the microelectronic substrate and external components; and

sealably enclosing the at least one recess with the thermal conductor positioned and configured to transfer heat from the active devices to a region external to the microelectronic substrate.

[c65] 65. The method of claim 64 wherein forming at least one recess includes etching at least one groove.

[c66] 66. The method of claim 64 wherein forming at least one recess includes forming a plurality of grooves.

[c67] 67. The method of claim 64 wherein disposing a thermal conductor includes placing a liquid in a position to absorb heat from the microelectronic substrate, vaporize, transfer heat to an enclosure member, and condense.

[c68] 68. A method of making a microelectronic device, comprising:

forming active devices at least proximate to a first surface of a microelectronic substrate, the microelectronic substrate having a second surface facing opposite from the first surface, the second surface having a projected area;

forming heat transfer surface features integrally in the second surface of the microelectronic substrate, wherein a surface area of the second surface including the heat transfer surface features is greater than the projected area; and

attaching to the microelectronic substrate a heat transport system with a thermal conductor configured to transfer heat from the active devices to a region external to the microelectronic device, the heat transport system being in thermal communication with the heat transfer surface features.

[c69] 69. The method of claim 68, wherein the thermal conductor is the second of two thermal conductors, and wherein the method further comprises disposing a first thermal conductor between at least some of the heat transfer surface features on the microelectronic substrate.

[c70] 70. The method of claim 68 wherein forming heat transfer surface features includes forming a plurality of projections.

[c71] 71. The method of claim 68 wherein attaching to the microelectronic substrate a heat transport system includes adhering the heat transport system to the microelectronic substrate with a nitride adhesive.

[c72] 72. A method of cooling a microelectronic device, comprising:

providing a microelectronic substrate having a first surface, a second surface with a plurality of surface features, and a plurality of active devices at least proximate to the first surface, wherein the plurality of surface features is not configured to provide electrical communication between the microelectronic substrate and components external to the microelectronic substrate; and

absorbing heat from the second surface through a heat transport system with a thermal conductor configured to transfer heat from the active devices to a region external to the microelectronic device.

[c73] 73. The method of claim 72 wherein absorbing heat from the second surface includes:

heating the thermal conductor proximate to a first portion of the heat transport system;

vaporizing at least a portion of the thermal conductor; and

condensing the vaporized thermal conductor at least proximate to a second portion of the heat transport system.

[c74] 74. The method of claim 72 wherein the thermal conductor is the second of two thermal conductors and wherein the microelectronic substrate includes a first thermal conductor proximate to the surface features, and wherein absorbing heat from the second surface includes:

heating the first thermal conductor;

transferring heat between the first thermal conductor and the heat transport system;

heating the second thermal conductor proximate to a first portion of the heat transport system;

vaporizing at least a portion of the second thermal conductor; and

condensing the vaporized second thermal conductor at least proximate to a second portion of the heat transport system.